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(54) **METHODS, SYSTEMS, AND APPARATUS TO DETERMINE A CLOT CARRYOUT CONDITION UPON PROBE RETRACTION DURING SAMPLE ASPIRATION AND DISPENSING**

(76) Inventors: **Alexander Vidlak Evers**, Wilmington, DE (US); **Bridgett Angela Harris**, Elkton, MD (US); **Alexander Openstone**, Wilmington, DE (US); **Jeffrey Kenneth Parmer**, Newark, DE (US)

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G01N 33/49 (2006.01)

(52) **U.S. Cl.**
CPC ***G01N 35/1009*** (2013.01); *G01N 33/4905* (2013.01); *G01N 2035/1018* (2013.01)

(58) **Field of Classification Search**
CPC G01N 35/1009
See application file for complete search history.

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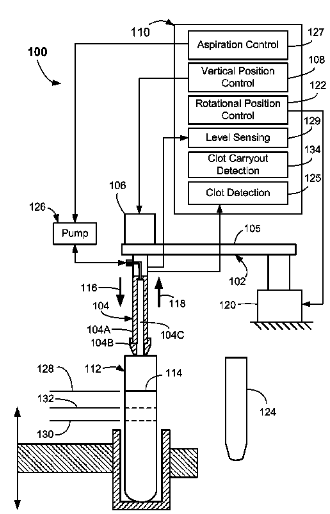
Primary Examiner — Peter Macchiarolo
Assistant Examiner — Nathaniel Kolb
(74) *Attorney, Agent, or Firm* — Dugan & Dugan, PC

(57) **ABSTRACT**

A method of determining a condition of clot carryout from a sample container containing a sample fluid is disclosed. During aspiration of a fluid sample (e.g., blood), a level sensor, such as a capacitance sensor, is used to measure ascending and descending liquid level readings. A difference between the ascending and descending liquid level readings may be compared to a predetermined threshold. Non-ideal conditions, such as a clot carryout condition wherein a clot is carried out of the sample container on the exterior surface of the probe may be detected thereby. Systems and apparatus for carrying out the method are provided, as are other aspects.

17 Claims, 3 Drawing Sheets



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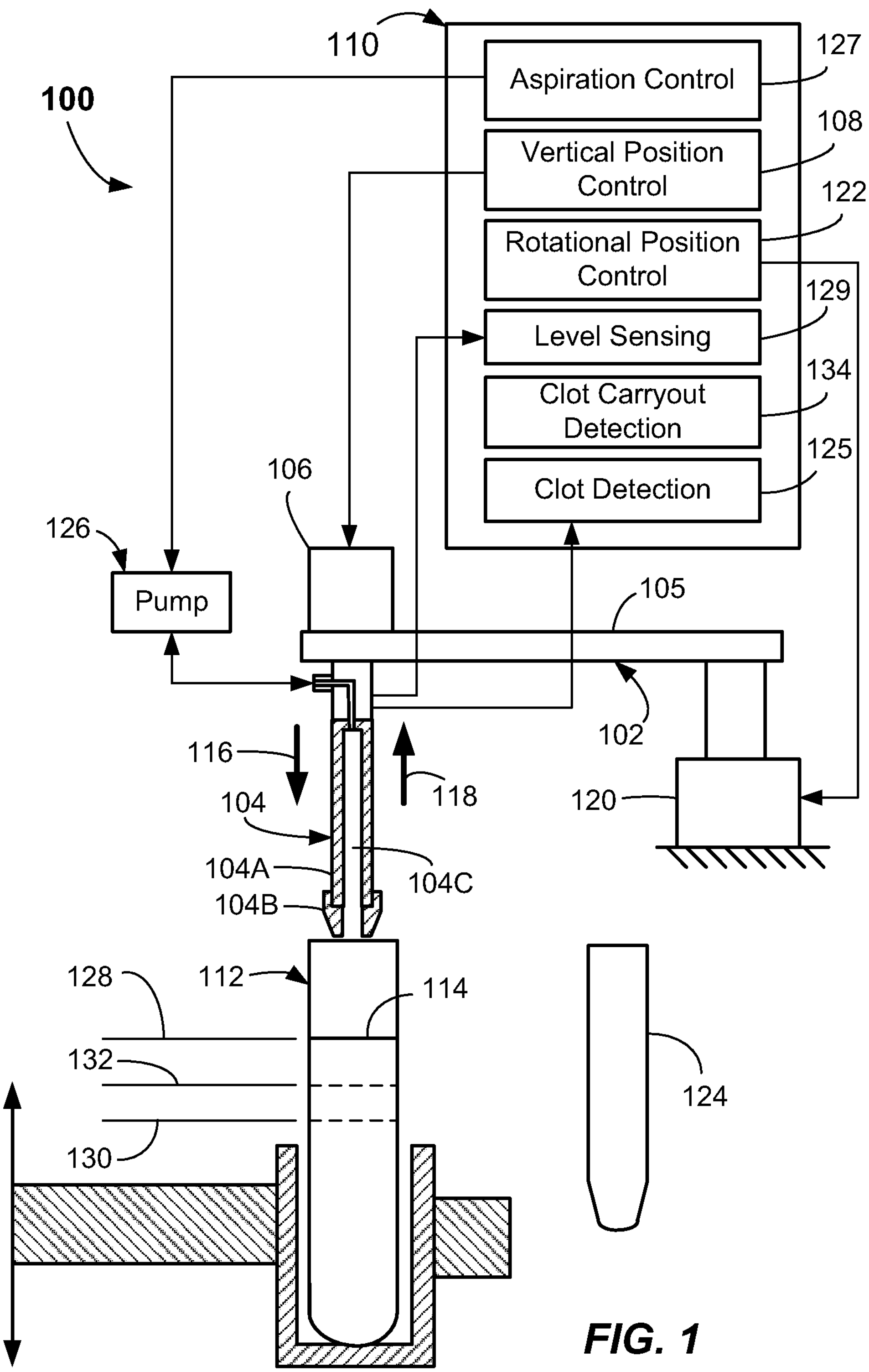
100
110
Aspiration Control
127
Vertical Position Control
108
Rotational Position Control
122
Level Sensing
129
Clot Carryout Detection
134
Clot Detection
125
106
126
Pump
105
102
116
118
104
104A
104B
104C
120
112
114
128
132
130
124

FIG. 1

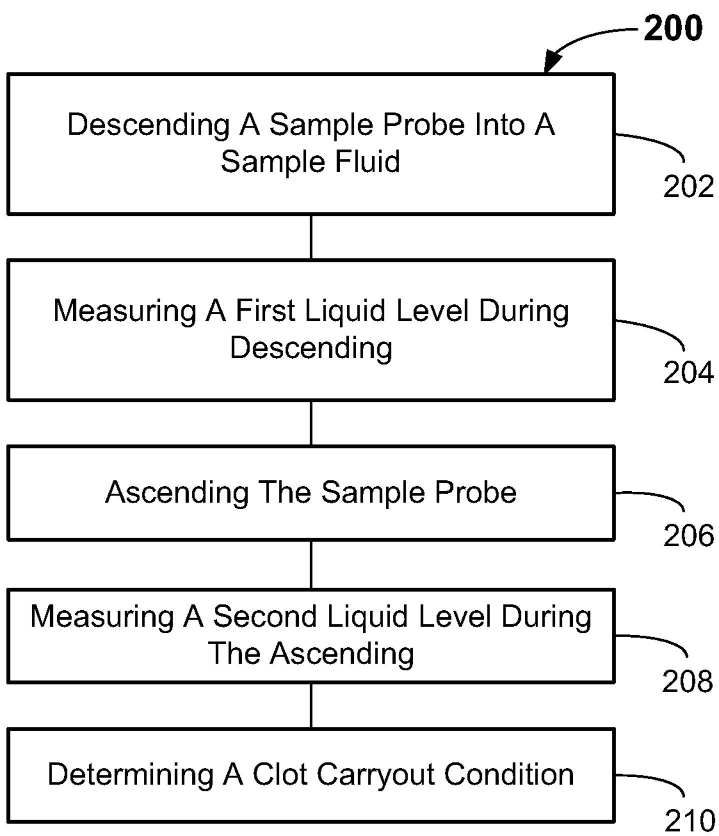
200
Descending A Sample Probe Into A Sample Fluid
202
Measuring A First Liquid Level During Descending
204
Ascending The Sample Probe
206
Measuring A Second Liquid Level During The Ascending
208
Determining A Clot Carryout Condition
210

FIG. 2

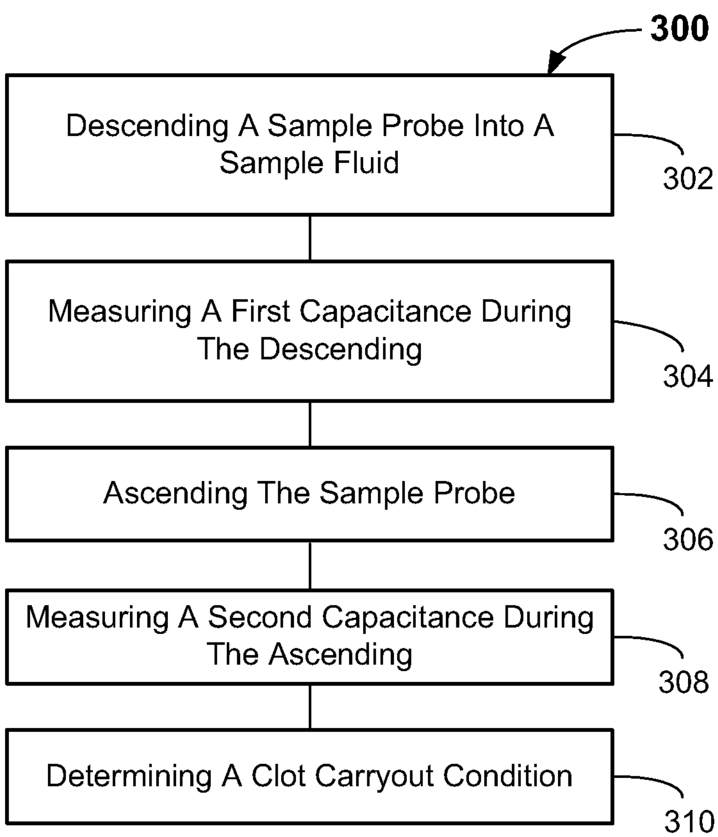
300
Descending A Sample Probe Into A Sample Fluid
302
Measuring A First Capacitance During The Descending
304
Ascending The Sample Probe
306
Measuring A Second Capacitance During The Ascending
308
Determining A Clot Carryout Condition
310

FIG. 3

METHODS, SYSTEMS, AND APPARATUS TO DETERMINE A CLOT CARRYOUT CONDITION UPON PROBE RETRACTION DURING SAMPLE ASPIRATION AND DISPENSING

RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application Ser. No. 61/297,379 entitled "Methods, Systems, and Apparatus to Determine A Clot Carryout Condition Upon Probe Retraction During Sample Aspiration and Dispensing" filed on Jan. 22, 2010, the disclosure of which is hereby incorporated by reference in its entirety herein.

FIELD OF THE INVENTION

The present invention relates generally to methods, systems, and apparatus for determining the presence of clots during aspiration and dispensing of samples in clinical analyzers.

BACKGROUND OF THE INVENTION

In testing within clinical laboratories to measure various chemical constituents of body fluids obtained from patients, such as whole blood, blood serum, blood plasma, and the like, automated clinical analyzers may reduce the number of trained technicians required to perform the analyses, improve accuracy of the testing, and reduce the cost per test.

Typically, an automated analyzer includes an automated sample fluid aspirating and dispensing system, which is adapted to aspirate a sample of body fluid from one sample container and dispense the body fluid sample into another reaction container (e.g., a cuvette). The sample body fluid aspirating and dispensing system typically includes a pipette (otherwise referred to as a "sample probe") mounted on a moveable arm, to perform the aspiration and dispensing functions.

One or more chemical reagents, which are specific to the test to be performed, may be disposed into the reaction container, thereby mixing the body fluid sample with the chemical reagent. By examining the reaction products resulting from mixing the body fluid sample and the reagent(s), the automated analyzer may determine a concentration of a specific chemical constituent contained therein. Upon completion of the testing, the automated analyzer may store or print the results of the test.

During the aspiration operation, the moveable arm, which may be under the control of a robotic controller, may position the sample probe above the sample container, and descend the probe into the container until the probe is partially immersed in the body fluid sample in the container. A pump or other aspirating device is then activated to draw (aspirate) a portion of the body fluid sample from the sample container into the probe. The probe is then ascended (retracted) from the sample container such that the body fluid sample may be transferred to the reaction container for testing. During the ascending step, sometimes clotted fluid (a clot, such as a fibrin clot) may be pulled (carried out) of the sample fluid on the probe. These types of clots carried out by the probe may be quite sizeable. In some instances, the clot may fall from the probe, and this may possibly contaminate the analyzer, areas around the analyzer, and/or possibly affect the test results of the sample being tested (or even other samples). Accordingly, the inventors recognized there is a need for determining such occurrences of clot carryout during probe ascending, such that the aforementioned problems may be avoided.

SUMMARY OF THE INVENTION

The present invention provides a method for detecting clots during aspiration and dispensing of a sample fluid. The method includes descending a sample probe into a sample container containing the sample fluid, measuring a first level reading during the descending, ascending the sample probe, measuring a second level reading during the ascending, and determining a clot carryout condition based upon the first level reading and the second level reading.

According to another aspect, the present invention provides a method for detecting clots during aspiration and dispensing of a sample fluid. The method includes descending a sample probe into a sample container containing the sample fluid, measuring a first capacitance reading during the descending, ascending the sample probe, measuring a second capacitance reading during the ascending, and determining a clot carryout condition based upon the first and second capacitance readings.

According to another aspect, the present invention provides a method for detecting clots during aspiration and dispensing of a sample fluid. The method includes providing a sample probe, descending the sample probe into a sample container containing a volume of the sample fluid, measuring a first capacitance reading during descending as the probe first contacts a surface of the sample fluid, drawing at least some of the sample fluid into the sample probe, determining the presence of a clot condition within the inner passage of the sample probe, ascending the sample probe, measuring a second capacitance reading during the ascending, and determining the presence of a clot carryout condition based on a difference between the first capacitance reading and the second capacitance reading, wherein the clot carryout condition is where a clot is carried out on an external surface of the sample probe.

According to another aspect, the present invention provides an aspirating and dispensing system. The system includes a sample probe, a robot component adapted to descend and ascend the sample probe into and out of a volume of sample fluid contained in a sample container, an aspirator adapted to draw the sample fluid into an inner passage of the sample probe, level sensing adapted to measure a descending liquid level during descending and an ascending liquid level during ascending, and clot carryout detection adapted to determine a presence of a clot carryout condition based on the descending and an ascending liquid levels, wherein the clot carryout condition is where a clot is carried out on an external surface of the sample probe.

According to another aspect, the present invention provides an aspirating and dispensing apparatus. The aspirating and dispensing apparatus includes a sample probe including a sensor, and a controller coupled to the sensor, the controller adapted to record a descending liquid level sensed by the sensor during descending, record an ascending liquid level sensed by the sensor during ascending, and determine a presence of a clot carryout condition based on the descending and ascending liquid levels, wherein the clot carryout condition is where a clot is carried out on an external surface of the sample probe.

Still other aspects, features, and advantages of the present invention may be readily apparent from the following detailed description by illustrating a number of exemplary embodiments and implementations, including the best mode contemplated for carrying out the present invention. The present

invention may also be capable of other and different embodiments, and its several details may be modified in various respects, all without departing from the spirit and scope of the present invention. Accordingly, the drawings and descriptions are to be regarded as illustrative in nature, and not as restrictive. The drawings are not necessarily drawn to scale. The invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood by referring to the detailed description taken in conjunction with the following drawings.

FIG. **1** is a schematic diagram of an aspirating and dispensing system according to the present invention.

FIG. **2** is a flow chart illustrating methods according to embodiments of the present invention.

FIG. **3** is another flow chart illustrating methods according to embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In view of the foregoing difficulties, there is an unmet need to reduce the propensity for carrying clots out of the sample container that have clung onto the outside of, or otherwise extend out of, the sample probe. To address this need, embodiments according to aspects of the present invention provide a method of detecting the presence of clot carryout condition upon retraction (ascending of the probe out of the sample container). The method includes a level detection function, which detects both a descending liquid level and an ascending liquid level. A difference between these liquid levels may be used to determine the presence of the clot carryout condition. In particular, a difference above a predetermined threshold value may be used to signal the presence of a clot carryout condition.

In some embodiments, capacitance readings may be used to determine the descending and ascending liquid levels. However, any method of level detection may be used with the present invention. In some embodiments, conventional clot detection may be used in conjunction with the clot carryout detection method of the present invention. In this manner, if a small clot is detected by a conventional clot detection method, then movement of the probe and the sample to a drain may be safely carried out, without fear of contaminating the analyzer or surroundings if the clot carryout detection of the present method determines that no clot carryout condition is present.

These and other aspects and features of the invention will be described with reference to FIGS. **1**-**3** herein.

Referring to FIG. **1**, an aspirating and dispensing system **100** is illustrated. The aspirating and dispensing system **100** includes any suitable moving component(s) **102** for carrying out motion of a sample probe **104**. The moving component **102** may include a robot component **105** (e.g., robot arm) to which the sample probe **104** may be mounted. The robot component **105** may swing about a fixed axis to provide horizontal motion capability, for example. Further, vertical motion of the sample probe **104** along a vertical axis may be imparted by a linear actuator **106** of the moveable component(s) **102**, which may be coupled to the probe **104**.

The linear actuator **106** may be actuated by a vertical position control **108** of a controller **110**. The actuator **106** may be operable to descend and ascend the sample probe **104** into and out of a sample container **112** containing a volume of a sample fluid **114**, at least some of which is to be tested. In particular, the sample probe **104** may be actuated along the directions indicated by arrow **116** (descending the probe **104**) and arrow **118** (ascending or retracting of the probe **104**).

Additionally, the moving component(s) **102** may include a rotational actuator **120**, which may be controlled by rotational position control **122** of the controller **110** to rotate the moving component(s) **102** and sample probe **104** along a horizontal (e.g., an arcuate path) from a position above the sample container **112** to a position above a reaction container **124** (e.g., a cuvette). Other types of components for imparting vertical motion may be used. For example, the rotational actuator **120** may also include vertical motion capability. Similarly, a gantry system may be employed wherein the probe **104** may be attached to a beam of a gantry moveable in the vertical and horizontal directions.

An aspirator **126**, such as a pump, may be coupled, such as by a section of hollow tube or conduit, to the sample probe **104** to allow a suitable amount of the sample fluid **114** to be drawn into the inner passage **104**C of the sample probe **104** for testing. Aspirator **126** may also have other functions, such as aspirating and dispensing reagent and/or diluting materials, and may also dispense rinsing fluids. Aspiration control **127** of the controller **110** may be adapted, and operational, to control a level of pressure to draw in a desired amount of the sample fluid **114** into the probe **104**, and also to control the dispensing operations performed by the aspiration and dispensing system **100**. The aspirator **126** may include suitable pressure sensor(s), valve(s), accumulator(s), or other pneumatic or hydraulic components (not shown) to effectuate the fluid drawing action. Any suitable apparatus for drawing the fluid into the probe **104** may be used. For example, aspirating and dispensing systems, which may be used with the present invention, are described in U.S. Pat. Nos. 7,634,378; 7,477,997; and 7,150,190, which are hereby incorporated by reference herein.

Typically, the sample probe **104** includes a probe body **104**A and a probe tip **1048**. The tip **1048** may be disposable and removably coupled to the probe body **104**A. A supply of tips **1048** may be stored nearby where they may be accessed by the probe body **104**A upon movement by the robot component **102**. However, in some applications, a non-disposable tip permanently secured to the probe body **104**A may be used. In this instance, a washing and rinsing station may be located within the reach of the robot component **102**. The probe **104** includes the inner passage **104**C into which at least a portion of the sample fluid **114** is drawn.

In some embodiments, the aspiration and dispensing system **100** may include additional components/systems, such as clot detection **125** adapted to sense the presence of a clot within the passage **104**C of the probe **104**. For example, pressure (as measured by a pressure sensor coupled to the probe passage **104**C—not shown) may be sensed to determine the presence of a clot, such as is described in U.S. Pat. No. 7,477,997, which is hereby incorporated by reference herein. Any conventional clot detection method may be used.

In operation, during aspiration, the robot component(s) **102** position the sample probe **104**, with a probe tip **1048** attached, above the sample container **112** and descends the sample probe **104** at a predetermined rate along the descending direction **116**. The descent into the container **112** is produced by the action of the linear actuator **106** under the control of the vertical position control **108** until the probe **104** reaches the surface of the sample fluid **114** therein. When the probe **104** touches the fluid surface, level sensing **129**, which may be provided by a capacitance detection circuit, determines that the surface of the sample **114** has been reached. For example, the capacitance detection circuit may detect the surface by detecting an initial step change in a measured capacitance, which is above a threshold value. Once the fluid surface is detected, the vertical position control **108** records a vertical position of the sample probe **104** when first contacting the surface as the "descending liquid level" illustrated by line **128**. The vertical position control **108** may control the linear actuator **106** to continue the descent along direction **116** to a predetermined level **130** (illustrated by the lower dotted line), which is below the descending liquid level **128**. Capacitance liquid level measuring is described, for example, in U.S. Pat. No. 7,150,190, which is hereby incorporated by reference herein. Other types of level detection may be employed.

Now the aspirator **126** may be operated via aspiration control **127** to draw off a predefined volume of the fluid sample **114** into the inner passage **104**C of the sample probe **104**. As the pump **126** is operated, the level of sample fluid **114** in the sample container **114** is drawn down, i.e., lowered. When a desired amount of sample fluid **114** has been received within the sample probe **104**, as measured by aspiration control **127**, the pump **126** may be stopped such that no further aspiration of the sample fluid **114** occurs.

After the desired volume of sample fluid **114** has been aspirated into the probe **104**, the sample probe **104** is ascended along arrow **118** to retract the probe **104** from the sample container **112**, such that a portion of the sample **114** may be transferred to the reaction container **124**. As the probe ascends along direction **118**, level sensing **129** again may sense a step change in capacitance above a predetermined threshold level. This second step change, when detected, may be recorded as the "ascending liquid level" and is designated as **132** (the upper dotted line).

Of course, in the absence of a clot carryout condition, i.e., adhering of a clot to the outside surface of the probe or otherwise extending out of the passage **104**C of the probe **104**, the second level **132** may be roughly determinable. In the absence of a clot being carried, the level is based upon the initial level, the volume of fluid displaced as the sample probe **104** is submerged into the fluid to the desired depth, and the volume of fluid aspirated from the sample container **112** based upon knowing the pressure and exact dimensions of the probe **104**. However, surface tension effects will cause the ascending liquid level to be measured as slightly higher than the rough calculations would indicate, because the sample fluid **114** adheres or clings via surface tension to the surface of the probe **104**. However for a non-clotted sample, the ascending liquid level **132** can be determined experimentally and used in the method as will be described herein. For example, the average ascending level may be determined experimentally by averaging a number of aspirations that are known to be free of clot carryout conditions.

In the event that the clot detection **125** detects conditions that indicate the possible or likely presence of a clot in the aspirated sample within the inner passage **104**C, then the recorded values of the descending liquid level **128** and the ascending liquid level **132** may be further utilized. The levels **128**,**132** may be used to determine if a clot is being carried out of the sample container by the probe **104** (to determine a "clot carryout condition"). The clot detection **125** may be accomplished by any suitable method, such as described in U.S. Pat. Nos. 7,867,769, 7,634,378; 7,477,997; 6,119,533; 6,060,320; and 6,022,747.

According to the invention, the presence of a clot carryout condition is determined by clot carryout detection **134** based on the recorded descending liquid level **128** and the recorded ascending liquid level **132**. In particular, the presence of a clot carryout condition may be determined based upon a difference between the recorded descending liquid level **128** and the recorded ascending liquid level **132**. If the difference is above (greater than) a predetermined threshold value, then clot carryout detection **134** may determine that a clot carryout condition is present, i.e., a mass of a clotted sample material (e.g., a fibrin clot) may be adhered to or otherwise connected to, or hanging from, the sample probe **104**. Accordingly, upon a determination of a clot carryout condition being present, corrective measures may be undertaken by the vertical and rotational controls **108**, **122**. For example, the vertical and rotational controls, **108**, **122** may simply halt or stop any further motion of the probe **104**. This may allow appropriate remedial measures (as discussed below) to take place. The predetermined difference between the descending and ascending liquid levels **128**, **132** may be set to be about 1.5 or more times, about 2 or more times, about 3 or more times, or even 4 or more times an expected difference between the descending liquid level and the ascending liquid level established for un-clotted sample materials. The expected difference value may be determined experimentally through averaging a series of tests and determinations of the descending and ascending liquid level readings where no clotting is apparent.

Remedial measures may include stopping further vertical motion of the probe **104** along direction **118**, operator intervention, wash or rinse in place (without moving), or preliminary wash or rinse followed by moving the probe **104** to a wash area or station where additional wash or rinse steps may be accomplished. Stopping the probe **104** when a clot carryout condition is detected by clot carryout detection **134** may prevent a clot from ever leaving the confines of the sample container **112**, or if the clot should drop from the sample probe **104** it may fall directly into the sample container **112**. Accordingly, instances of contamination of the clinical analyzer, its surroundings, and/or other samples and instances of analyzer downtime may possibly be avoided by utilizing the present invention.

Referring now to FIG. **2**, a broad method of the invention is illustrated. The method **200** is adapted to detect a clot carryout condition during aspiration and dispensing of a sample fluid. According to embodiments, the method **200** includes, in **202**, descending a sample probe (e.g., sample probe **104**) into a sample container (e.g., sample container **112**) containing the sample fluid (e.g., sample fluid **114**). This is followed by measuring a first liquid level (e.g., descending level **128**) reading during the descending, in **204**. After a suitably-sized portion of the sample fluid has been aspirated via the action of the aspirator (e.g., aspirator **126**), the sample probe may be ascended in **206**, such as under the action of the vertical position control **108** (See FIG. **1**). A second liquid level reading (e.g., ascending level **132**) is measured during the ascending, in **208**. Finally, in **210**, the presence or absence of a clot carryout condition is determined. According to embodiments, the presence or absence may be determined based upon a difference between the first and second liquid level readings (e.g., difference between the descending level **128** and the ascending level **132**). In particular, if the difference is above a predetermined threshold value, a clot carryout condition is determined. Accordingly, remedial measures may be undertaken, such as described above. If no clot carryout condition is determined, i.e., the difference is below the threshold, then the system **100** (See FIG. **1**) may continue with dispensing the fluid sample into the reaction container **124** (e.g., a cuvette) for testing, followed by movement to a drain station at another location, possibly followed by wash and/or rinse steps.

In accordance with some embodiments of the invention, a method for detecting clots during aspiration and dispensing of sample fluid wherein the level sensing is accomplished by measuring capacitance is provided. The method **300**, as illustrated in FIG. **3**, may include, in **302**, descending a sample probe (e.g., sample probe **104**) into a sample container (e.g., sample container **112**) containing a sample fluid (e.g., **114**), followed by measuring a first capacitance reading during the descending, in **304**. The first capacitance reading is determined by a jump in capacitance measured by the level detection **129** when the probe first touches the surface of the sample fluid **112**. Following aspiration of a suitable portion of the sample fluid by the action of an aspirator **126** and aspiration control **127**, the sample probe **104** (See FIG. **1**) is ascended, in **306**. A second capacitance reading is measured during the ascending, in **308**, by the level detection **129**. The second level is determined by another jump in the capacitance as the probe (or clot) separates from the surface of the fluid sample. Following the level sensing, a clot carryout condition is determined in **310** by clot carryout detection algorithm. The clot carryout condition, as described above, may be based upon the first and second capacitance readings. In particular, a difference between the measured capacitance levels may be measured. If that difference is above a predetermined threshold value, then a clot carryout condition is determined, and remedial measures, as discussed above, may be undertaken.

Having shown the preferred embodiment, those skilled in the art will realize many variations are possible that will still be within the scope and spirit of the claimed invention. Therefore, it is the intention to limit the invention only as indicated by the scope of the claims.

What is claimed is:

1. A method for detecting clots during aspiration and dispensing of sample fluid, comprising:
- descending a sample probe into a sample container containing the sample fluid;
- measuring a first level reading during the descending;
- ascending the sample probe;
- aspirating at least a portion of the sample fluid, and detecting a presence of a clot condition in an inner passage of the sample probe;
- measuring a second level reading during the ascending; and
- determining a clot carryout condition on an exterior of the probe based upon the first level reading and the second level reading
- wherein upon determining the clot carryout condition exists, the ascending movement of the sample probe is stopped to prevent contamination by preventing a clot from leaving the confines of the sample container.

2. The method of claim **1**, wherein the presence of a clot carryout condition is based upon a difference between the first level reading and the second level reading.

3. The method of claim **2**, wherein the presence of a clot carryout condition is based upon the difference being greater than a predetermined threshold value.

4. The method of claim **3**, wherein the predetermined threshold value is 1.5 or more times an expected difference between a descending liquid level and an ascending liquid level established for un-clotted sample materials.

5. A method for detecting clots during aspiration and dispensing of sample fluid, comprising:
- descending a sample probe into a sample container containing the sample fluid;
- measuring a first capacitance reading during the descending;
- aspirating at least a portion of the sample fluid, and detecting a presence of a clot condition in an inner passage of the sample probe;
- ascending the sample probe;
- measuring a second capacitance reading during the ascending; and
- determining a clot carryout condition based upon the first and second capacitance readings
- wherein upon determining the clot carryout condition exists, the ascending movement of the sample probe is stopped to prevent contamination by preventing a clot from leaving the confines of the sample container.

6. The method of claim **5**, wherein the presence of a clot carryout condition is based upon a difference between the first and second capacitance readings.

7. The method of claim **6**, wherein the presence of a clot carryout condition is based upon the difference being greater than a predetermined threshold value.

8. The method of claim **5**, wherein
- if the clot carryout condition exists, then then the ascending of the sample probe is stopped, and
- if the clot is detected in the inner passage, but no clot carryout condition exists, then then the ascending of the sample probe is not stopped.

9. The method of claim **5**, wherein
- if the clot carryout condition exists, then then the ascending of the sample probe is stopped, and
- a wash or rinse in place is carried out.

10. A method for detecting clots during aspiration and dispensing of sample fluid, comprising:
- descending a sample probe into a sample container containing the sample fluid;
- measuring a first capacitance reading during the descending;
- aspirating at least a portion of the sample fluid, and detecting a presence of a clot condition in the inner passage of the sample probe;
- ascending the sample probe;
- measuring a second capacitance reading during the ascending;
- determining a clot carryout condition based upon the first capacitance reading and the second capacitance reading, wherein if the clot is detected in the inner passage of the sample probe, and the difference between the first capacitance reading and the second capacitance reading is below a predetermined threshold value, then the movement of the sample probe is not stopped.

11. A method for detecting clots during aspiration and dispensing of sample fluid, comprising:
- providing a sample probe;
- descending the sample probe into a sample container containing a volume of the sample fluid;
- measuring a first capacitance reading during descending as the probe first contacts a surface of the sample fluid;
- drawing at least some of the sample fluid into the sample probe;
- determining a presence of a clot condition within an inner passage of the sample probe;
- ascending the sample probe;
- measuring a second capacitance reading during the ascending; and determining a presence of a clot carryout condition based on a difference between the first capacitance reading and the second capacitance reading, wherein the clot carryout condition is where a clot is carried out on an external surface of the sample probe
- wherein upon determining the clot carryout condition exists, the ascending movement of the sample probe is

stopped to prevent contamination by preventing a clot from leaving the confines of the sample container.

12. An aspirating and dispensing system, comprising:

a sample probe;

a robot component adapted to descend and ascend the sample probe into and out of a volume of sample fluid contained in a sample container;

an aspirator adapted to draw the sample fluid into an inner passage of the sample probe;

level sensing adapted to measure a descending liquid level during descending and an ascending liquid level during ascending;

clot detection adapted to determine a presence of a clot condition in an inner passage of the sample probe upon drawing the sample fluid into the inner passage; and

clot carryout detection adapted to determine a presence of a clot carryout condition based on the descending and ascending liquid levels, wherein the clot carryout condition is where a clot is carried out on an external surface of the sample probe

wherein upon determining the clot carryout condition exists, the ascending movement of the sample probe is stopped to prevent contamination by preventing a clot from leaving the confines of the sample container.

13. The aspirating and dispensing system of claim **12**, further comprising a controller adapted to determine an existence of the clot carryout condition.

14. The aspirating and dispensing system of claim **13**, further comprising a controller adapted to control a position of the robot component based upon an existence of the clot carryout condition.

15. The aspirating and dispensing system of claim **12**, wherein the level sensing is adapted to measure a change in capacitance.

16. The aspirating and dispensing system of claim **12**, wherein the clot carryout detection is adapted to determine a presence of a clot carryout condition based on a difference between the descending and ascending liquid levels.

17. An aspirating and dispensing apparatus, comprising:

a sample probe including a sensor, the sample probe including an inner passage and an external surface; and

a controller coupled to the sensor, the controller adapted to

record a descending liquid level sensed by the sensor during descending,

record an ascending liquid level sensed by the sensor during ascending,

detecting a presence of a clot condition within an inner passage of the sample probe upon aspirating a sample fluid,

determine a presence of a clot carryout condition based on the descending and ascending liquid levels, wherein the clot carryout condition is where a clot is carried out on an external surface of the sample probe

stop ascending if a clot carryout condition is determined.

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